Textured Yarn Technology
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Twist Texturing
Lecture – 06
Thermo-mechanical texturing

Alright so let us look back as to what we did in the last time that we met. We learned about what we call as the physics of setting.

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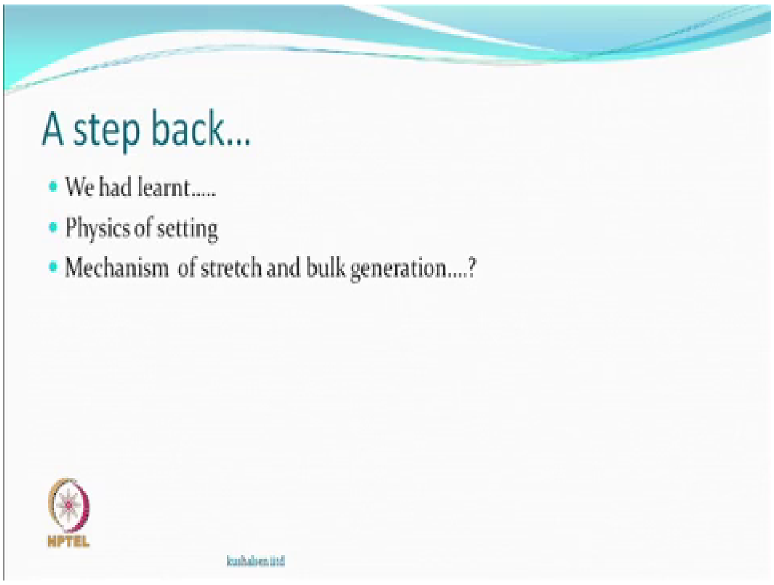

And mechanism of stretch and bulk generation. Did we do it all complete or there were something else was left for you to do. Did we ask something to do? No, did we discuss the role of detwisting?

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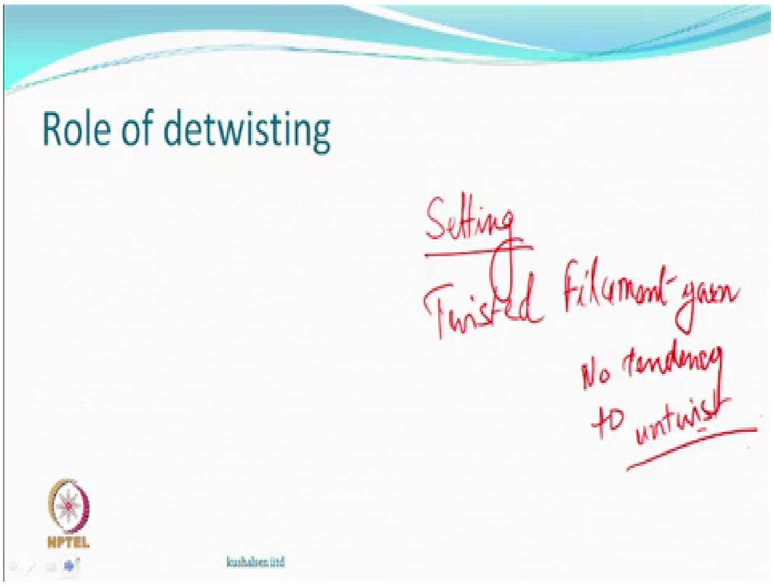

What was the role of the detwisting? Can you tell me why is the detwisting so important? See after setting you get a twisted filament yarn. This yarn does not have a tendency to untwist. So, what do we get at the end of setting; is that you have a multi filament yarn which has been tested and subjected to some setting operation. So, this yarn does not have any tendency to untwist, but it is not a textured yarn. So, what do we do?

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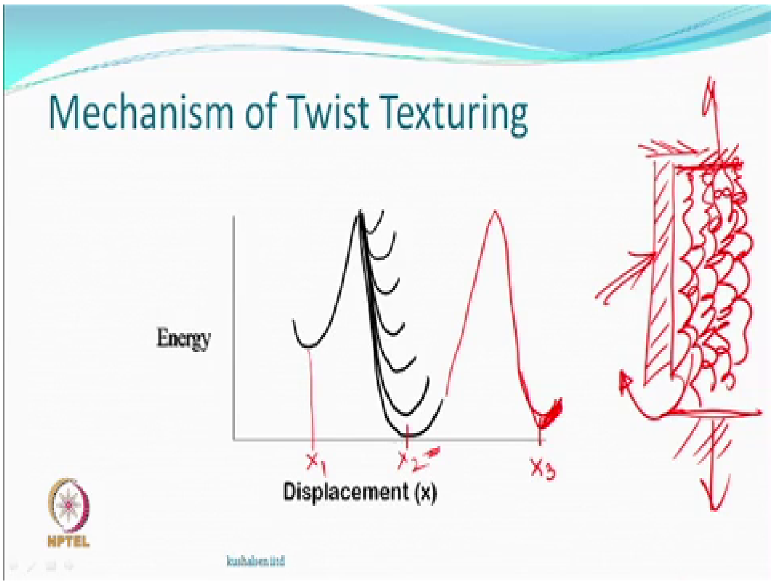

So, this was our position where though the untwisted multi filament yarn. There is another position where you had done some setting in this case, maybe it was a thermo plastic yarn and you did heat setting. And so the energy kept on coming down and became more stable. So, at the point X 2 it is a multi filament twisted yarn. So, it is not a textured yarn. So, what do we do? So, we say we do untwisting.

When we do untwisting the energy again goes up because you are doing against the wish of the twisted multi filament yarn. So, energy again goes up; energy obviously, would not like to remain at a higher state would like to come down. So, if you remove the untwisting forces what will happen? The yarn would like to go back and the filaments within the yarn would like to go back to their original position which they remember as the helical structure.

And so they will go back to the position which they remember. If all of them go back to position X 2, then what do you get? Again a multi filament twisted yarn, this again not a textured yarn. So, how do we get the stretch and how do we get the bulk? So, we had only three points twist, set and detwist and we have done the detwisting. So, how do you get the texture? How do you get the bulk? How do you get the stretch?

Any guess? We have completed the process the process that was defined and everybody was happy that this is the process interesting, isn't it. So, almost every time we thought twist set detwist you had a textured yarn and theoretically we say there is no textured yarn. So, this is a good situation to understand.

And therefore, if exactly the way this goes is what happens, if this is what happens then of course, we have a bad situation. Fortunately for us it does not happen, every filament remembers it is state of setting. But does not follow the process that it neighboring multi filament or neighboring filament is following it just goes the way it wants to go spontaneously wants to go back to it is designated position.

Which is what it remembers, but fortunately for us all of them take up another position which is X 3. And why this happens? Because going back to this is the more difficult option actually. Arbitrarily going anywhere is easy for example, if we tell this class to go out of this room in a single file it is a difficult option, everyone has to wait for the other and then follow. And if we do not say anything then everyone wants to go out in whichever manner they want to go out into the end we do not know who is gone out first who is gone later.

If this exactly that happens then we may not go to the position X 2 and if you do not go to X 2 there will be some other position which is X 3. From the energy point of view you may actually be at the same level. But the difference will be somewhere else and what is it? Suppose I have a yarn which was a twisted yarn.

And I give some force, fix this up and give some force so that it gets untwisted. Now for all of the filaments to take exactly the same position as they were before untwisting, then they have to actually follow exactly the same path as the untwisting. For that to happen you may have to have a situation where not only this is fixed this is also fixed and maybe there is another outfit. For example, something like that which and the yarn is held here and you have a mechanism to rotate only the inner part and then leave it, then this might come back. So, you have another fixture which is holding it ideally exactly the rotation axis of rotation of the yarn remains exactly same, does not change.

And so you twist it by fixing somewhere then untwist exactly in the same manner then there is a possibility that you can get this type of a situation where it becomes a multi filament twisted yarn. So, I said this does not happen. So, what happens? So there is no control mechanism when they want to go back and we are happy that there is no control mechanism.

So, when a twisted yarn is untwisted after that you just remove the untwisting force and then each filament would like to go to it is position which it remembers, but does not follow anyone. So, what happens? So, one filament it takes a position like this, the other filament also wants to go somewhere there, the third filament also goes and remember whatever it remembers the fourth filament also and so on and so forth.

All the filaments take up their position what they remember. But they do not want to go back to this shape because they do not know how to go; everyone wants to go immediately simultaneously without following any other instruction. And so what you get is a yarn which has more bulk and so if you stretch it can stretch also. So, this is the role of untwisting and if this did not happen then you will not get a textured yarn is that clear.

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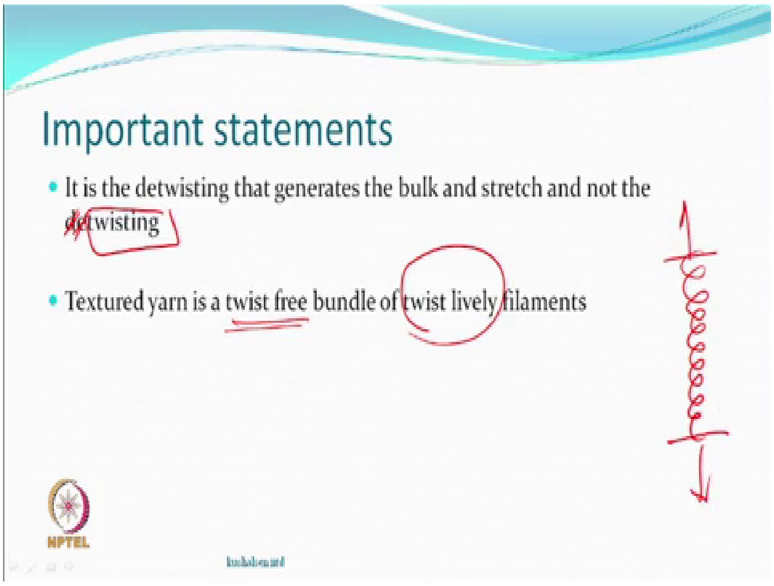

So, something which you may like to generally remember I call them statements. So, it is the detwisting that generates the bulk and stretch and not twisting, this is twisting. It is the detwisting that generates the bulk and stretch and not twisting. Twisting is important, but by twisting you are not getting bulk and stretch. You cannot say that I will not twist and get the same thing.

But finally, it is the detwisting which is responsible for generating the bulk and the stretch is that right clear. Textured yarn is a twist free bundle of twist lively filaments. So, there is no twist in the textured yarn, while we started with a multi filament yarn we did twisting, we did setting each filament remembered some of the parts that were traversed during this twisting process. But there is no twist in the textured yarn right.

But every filament is twist lively as if the energy is stored in them and they want to release the energy right. So, all of them like to go back to a ship. Although this word may not be the best to describe, but at some stage somebody who was explaining almost thought that a textured yarn maybe assuming some shape where the yarn is twisting over or filament is twisting over itself and therefore, is lively. So, you can stretch this whole thing opens and so on and so forth. But now we would rather believe that there is liveliness not because of twist.

So, there is a liveliness not because of twist, but because of maybe some structure like this alright, so there is a liveliness. So, each filament is lively in the sense you extend it will go back, but there is no overall twist in the yarn. And that is why you get what we get.

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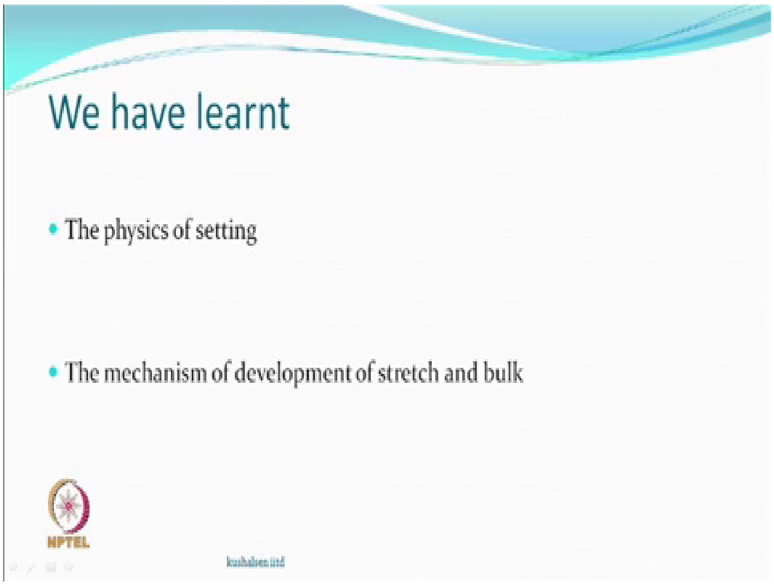

So what have you learned? Now we have learned; obviously, we can say that we have learned the physics of setting. And now we can also say more confidently that we know the mechanism of development of stretch and bulk alright. So, we go further. So, we will be talking now further on thermo mechanical texturing alright, thermo mechanical texturing; that means, you are looking at a yarn or a fiber which responds to heat. Mechanical because you are looking at still twisting which a mechanical process and so we will have that.

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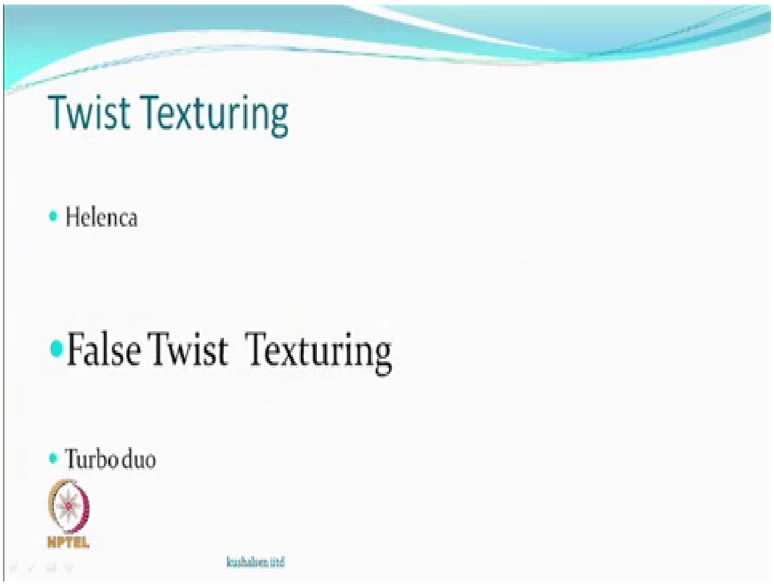

So, twist texturing, within that we are looking at twist texturing till the time we say that we are talking about something else. We are talking about twist texturing which means twisting is being used as the mechanism for deformation. And finally, hopefully if you do this you will produce a stretch yarn.

So, we know there are three methods, but whenever you want to assume anything think that we are talking about false detexturing and not talking about hellinca or talking about turbo duo or talking about this is more commercially successful and being used. Although all of them can be used without any problem and if you recall again.

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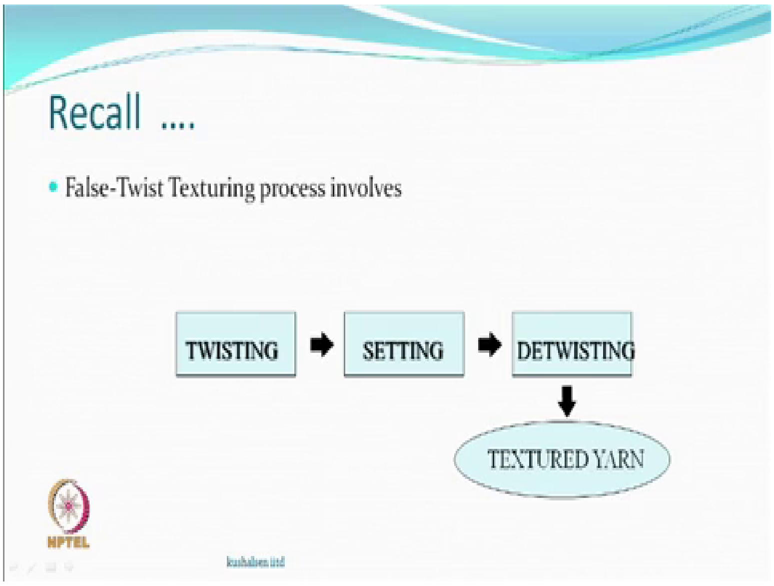

So, it will also involve the same thing called twisting, setting detwisting and the texturing yarn. And that is what we have understood today that how the textured yarn is produced.

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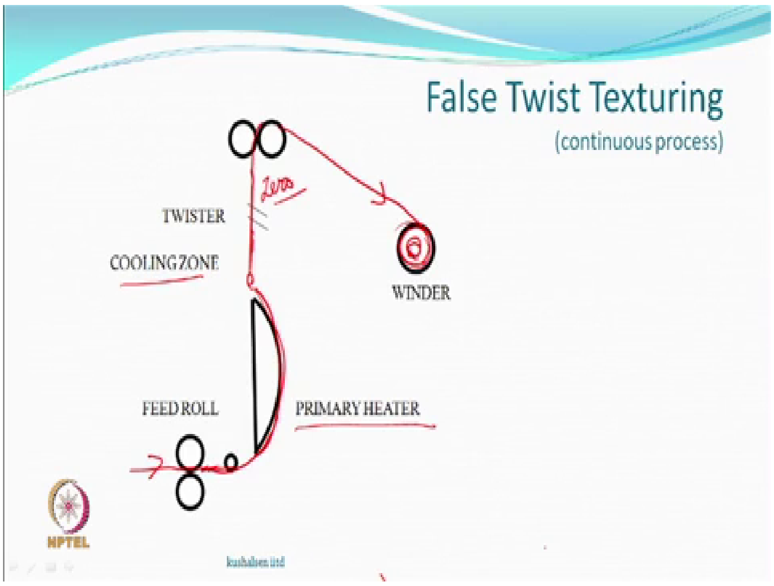

General line diagram we just remember. So, the yarn which is a untwisted yarn which is fed it goes over the heater surface. And then is guided through to the take up role and then to the winder where you can wind. This is your line diagram. So, remember there is a primary heater secondary heater is there therefore, the name remains primary heater.

So, you have a cooling zone then the heating zone and the twister. The twist above this is 0 I believe because you have untwisted. Below this zone there is a twist which flows down from this twister all the way to this point. So, you can appreciate hopefully there is this yarn this portion is a twisted portion right this whole is a twisted portion. Beyond this the twister does not flow above this there is no twist.

So, we have all the things as we have discussed before and this is where we will be working. You can appreciate we can talk about later that the level of twist in the yarn starting from the twister which is this point and going up to this may not be exactly same. You see will it be more here or more here, will it be more at this twister point or at the feed point yeah.

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Twisted, so, now confused about it so, twist level will reduce because there are constraints friction everything else is going to come play. And so if it was only a feed roller and take up roller and twist the situation would have been different. But because you are contacting a heater which also have some friction there are guides another guides and so all of them are going to play some role.

And plus the so called heater is not at room temperature. So, the yarn changes it is position also it is softness is rigidity also changes. So, because of that also there will be some change in the twist level as you move down from twister to the feed role.

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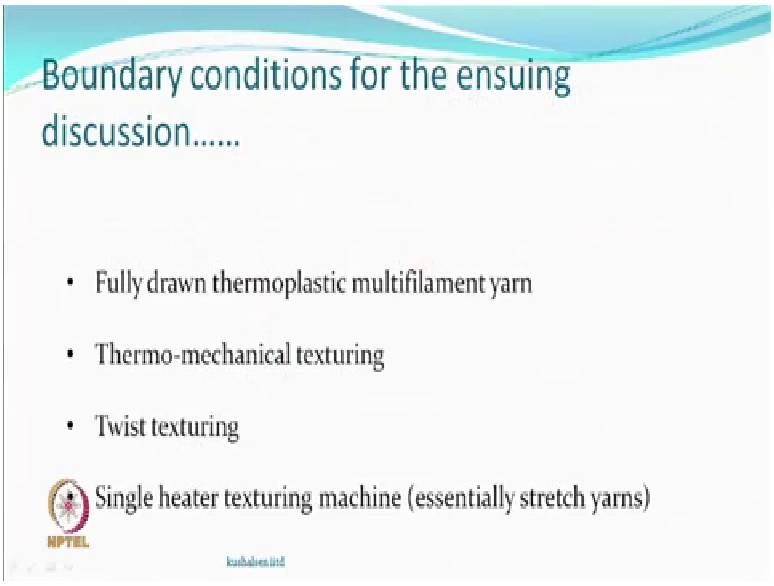

So, let us remember whenever we discuss and keep on discussing this texturing till the time we say well we are now changing the boundary conditions. We are assuming, they were discussing texturing of fully drawn thermo plastic multi filament yarn, fully drawn and it is thermo plastic that is one thing to remember.

Other thing is that twisting and thermo mechanical texturing is the process that we are using. It is twist texturing; that means, twisting and it is the single heater machine. So, essentially first we are looking at text stretch yarns alright. So, whenever you imagine anything some statement has been made, you must evaluate the statement under these conditions right not something else can happen; something else can happen. Of course, it can all happen.

So, fully drawn thermo plastic fibers because we know thermo plastic fibers multi filaments yarn need not be fully drawn, we are talking about thermal mechanical texturing because we can theoretically talk about thermo chemical texturing also. We are talking about twist texturing otherwise you could have said we are talking about or do our edge crimping no. We are only talking about this and a single heater machine at the moment false twist texturing alright.

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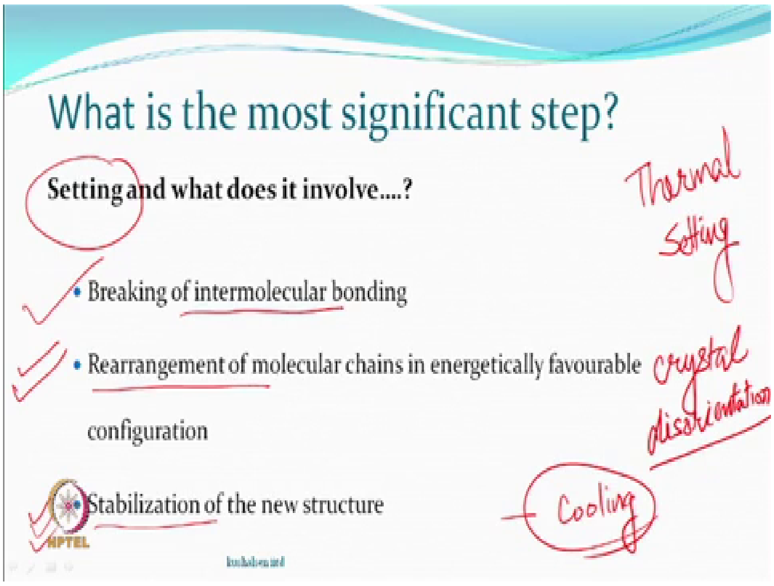

So, what is the most significant step? Out of the three steps that we have twisting setting and un twisting. So, while we said we made a statement that untwisting is very important yes, but if you do not do any setting there is nothing will happen anyway. So, we believe that setting becomes in any thermo plastic systems one of the more important contributors. And all those control system that you will develop will also be based on the need that the setting would want.

And what happens during the setting process? One thing which; obviously, and remember when we this is setting it is thermo mechanical we are putting heat. Breaking of inter molecular bonding. So, setting you said what was happening is that there will be release of energy and this release of energy will take place either by crystallization processes or by disorientation process are you getting my point. So, how will you get to these setting, how will you get to the set by release of energy.

And if you go by the release of energy then either there will be disorientation or crystallization both of them are favorable for us is that right. Then the first thing that must happen is breaking of inter molecular bonds. If these bonds are very strong and they do not break under whatever conditions that you set there will be no change. That means, the molecules within the fiber are going to change their positions and before that we were talking about filaments migrating getting setting and so on so forth.

Now we are talking about what exactly maybe happening. So, one of the things that must happen is there is going to be breaking of inter molecular bonding. And what would mean that the molecules that are there will be more free, they will respond to thermal energy increase their kinetic energy vibrate and do whatever they want to do and what will they will like to do. They will like to either crystallize or go to a disoriented state.

That is called the rearrangement. So, the molecular chains will rearrange in energetically favorable configuration. And that means, either they will go to the crystal formation or disorientation both are good for us. So, that is called the energetically favorable condition release of energy release of energy. And then third thing should also happen is stabilization in the new structure.

So, you have a new configuration what is the new configuration some molecular change they have done whatever they have done maybe they have folded over each other and made a crystallite region crystalline region. Or they have just been disoriented gone anywhere else now you must freeze them. If you do not if you do not stabilize the new structures this can keep changing then we are not going to be thing achieving our goals and so stabilization.

And this is in some sense is done by cooling. So, you do give thermal energy to increase kinetic energy and vibration when the molecules which help the breaking of intermolecular forces. Then you allow time enough time for recrystallization or crystallization or disorientation to happen. It is not a 0 time process some time is required that is an optimization. So, some energy for temperature how much temperature should be given some time should be given so that these things happen.

And then you say before untwisting remember the false twist immediately above the twister after the twister you have untwisting taking place. So, if this stabilization that is a cooling does not take place then you would have difficulty. And what I mean by cooling is at least the temperature of the yarn which may be quite high as it exists the heater. At least it brought down below the glass times in temperature are below which we expect much less transitions to take place right.

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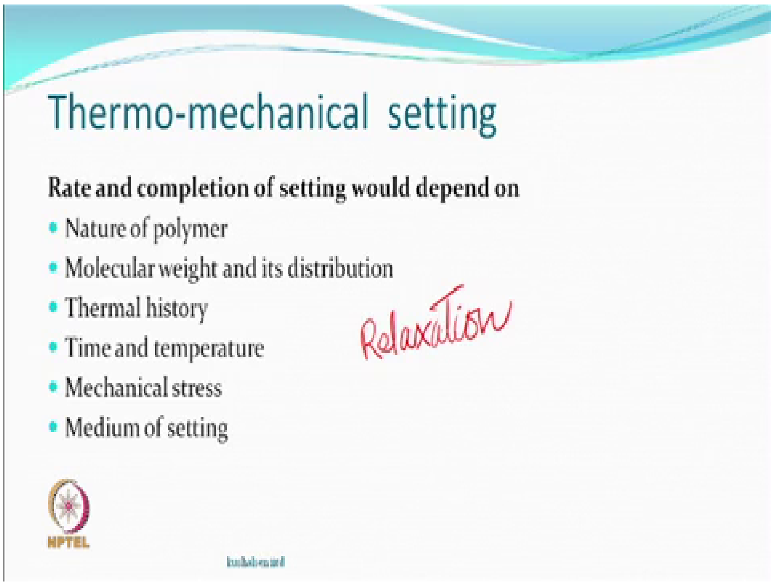

So if this is so then this is the thermo mechanical setting what does it involve? So, there is a rate; rate means time is involved. So, whenever we talk about rate there is a time. So, how fast the setting can take place and when do you think the setting is complete. So, these two things the completion and rate of setting would depend on some parameters alright. One is the polymer itself, is it nylon is it polyester is it polypropylene, their tendency to crystallize at any given temperature is different even at their own optimum temperatures also is different.

Some of the material for example, polyester is got aromatic rings in the chain, they are relatively more stable compared to let us say polypropylene which is aliphatic. And immediately has a tendency to go to some position which may be facilitated by nucleation so you can crystallize. So, rate of crystallization extent of crystallization of each polymer is different. So; obviously, it should depend on what kind of polymer that we use.

So, nature of polymer will be quite important ok. The molecular weight and distribution now this an important thing is unlike other molecules like carbon tetra chloride or water their molecular weight are fixed. And therefore, their properties are also very very specific and well defined. In a polymeric system the molecular weight of course, is a number. But it is very difficult to produce even nature cannot guarantee very easily that all the molecules of cellulose in cotton have the same molecular weight.

And when you polymerize synthesize there is no guarantee, only you can have more control. And therefore, you can do a better job. So, what is the molecular weight you understand depends on how you measure. So, weight averages number average those type of molecular weights you can always do viscosity average and so on so forth. But if we look at the curve, you will always get some curve of this type unless something wrong is happening. Like if after doing all the thing called polymerization the polymer is in solid state.

And then you do something what we call as solid state polymerization then you might find well it may not be such a beautiful curve it may be bi modal curve. So, some molecular weight of some type of more than the same. So, you may have to averages as if two types are formed. But let us say normal molecular weight. So, you have the average molecular weight of course, this will be the one and then this is the spread. So, this spread is the one which tells you whether the control were good or controls were not so good.

You can also have a situation where the average is same and you have a wider distribution. That means, molecules are very large molecular weight as well as molecules of smaller molecular weight are also pretty high. And in a common sense situation also one can appreciate that the entanglements, after all everything that is happening in fiber is due to entanglements of the molecules crystallization is there then the amorphous reason is there the molecules are entangled.

If there are short very short chains versus very long chains so, entanglement with the same chain may be very different and so the properties final properties also may not be same. And it is also possible that the smaller molecules can change their position much more easily compared to the larger ones. Therefore, this rate and completion of setting would also depend on this property, which you may measure you may not measure you may know about it you may not know about it while you are texturing.

Thermal history; that means, if suppose tomorrow we say well I have a beautiful filament yarn which has been just obtained after drawing we said multi filament. Oh no it also has been stored at a certain temperature for a certain period of time. So, was the temperature 30 degrees 50 degrees or you actually heat set it, fully drawn filament yarn heat set.

So, when you heat set something has changed all though polymer is same. So, nature of the polymer is same, molecular weight and distribution is same we have using same one. But I have given some additional thermal input also. Then what happens? Then some changes again in the nature of some crystallization some disorientation may have taken place. Before you have texturized and before you are doing a further setting.

And so this thermal history will also matter in this completion of setting. No doubt when we talk about polymer the moment you talk about rate. So, temperature will be an important parameter like polyester melts at what temperature, polyester that is PET.

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Alright, so 250 and above. And nylon 6?

Student: (Refer Time: 33:14).

Alright, 250 to 220. And polypropylene?

Student: (Refer Time: 33:19).

160 to 170 alright; so, based on what polymer you are looking at temperatures will have to change. And that we are not talking about melting temperature by the way; what we do? We go to a melting temperature we do a thermo mechanical setting. So, there will be another temperature which will be optimum temperature for setting purposes where the fiber remains intact, still looks like a fiber. But internally internal morphology is changing.

So, those type of temperatures are the one which are we going to used, we will talk about it later and time is important. As we said that unless the molecules are able to go to the best configuration which they like spontaneously based on thermodynamic conditions this will not happen; so, time and temperature are going to be very important.

Mechanical stress all those who have studied a bit of a structure properties of fibers, you can understand when we talk about a molecule taking a particular shape or configuration whether it is folding onto itself to make a crystalline region or it is randomly orienting itself; would depend on at that point what was the stress level in that filament.

Because all this is also called a relaxation process, relaxation molecular relaxation. So, when we said release of energy it is a relaxation you go to a disoriented set it is a relaxation. So, if you put additional stress then the molecule will be constrained by this stress and may not be able to take the best position because you are putting external stress. But you may have to do it sometimes for example, of the yarns or of the fabrics the heat setting sometimes is done in a very relaxed position or in a thought condition.

And they believe that if you heat set in a stressed condition then the orientation of the crystalline regions as well as those of the amorphous regions will be high, you may want it right. The molecules may not like it, but you want it and so what is the amount of stress that is there. If you remember, if you do the heat setting of the fabrics when it goes into the center right it is not under thought condition it goes as a relax condition you see the slack also and as it comes out to the center then the slack is gone some changes have taken place.

So, the how much slack that you have given will determine the final stress. So, you must appreciate that mechanical stress is going to also affect the rate and of course, then the completion. Medium of setting and normally we believe that we are talking about air as a medium right may not be you are now putting look at the false twist machine you are putting your yarn on the surface of a heater. Verses you had a choice that the yarn passes through a tube it does not touch.

So, conduction, convection radiation they can be also changing the rate at which the temperature the fiber rises, also theoretically you can think of the medium need not be air it could be a solvent. Because you might find that, if you go up to a certain temperature the filaments gets degraded a bit it becomes yellow. Since, I cannot go to that temperature but I have to go otherwise all this relaxation will not happen.

So, you say well is there any way? Well as we know that there can be way that you give another medium. So, you might find whatever is happening at temperature T 1 it can happen at half T 1 if you have solvent or any other kind of a systems that you have. So, medium can change all these things right.

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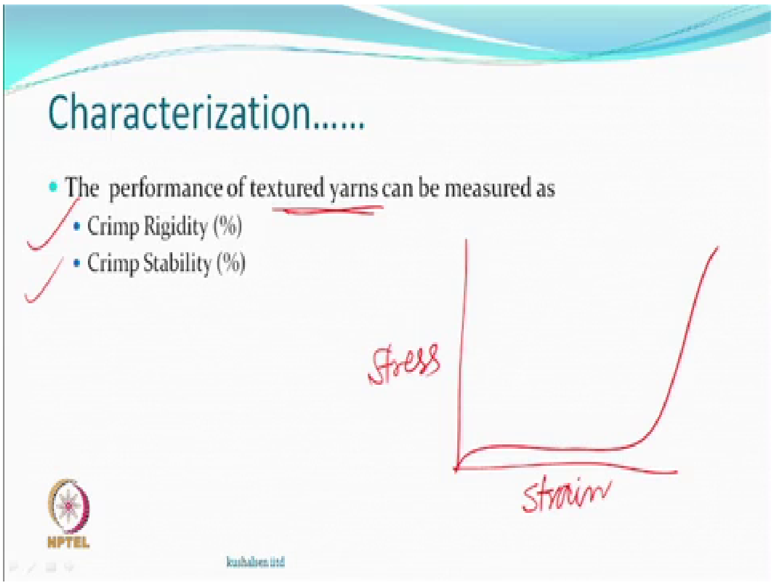

So, we have few minutes. So, let us say before we go for any kind of optimization and so on and so forth one must know how do we characterize something called a textured yarn. So, there are two parameters one is called crimp rigidity and the other is called crimp stability. I mean when we characterize a textured yarn of course, we may be interested in tensile properties also, breaking stress breaking elongation modulus (Refer Time: 39:11) tested.

But, if you remember the stretch yarn; so, the curve is like this and what does it mean? It means that the final tenacity at break may not be so important. Because it can stretch 350 percent before it takes up the real stress. So, why something gets stressed is because I bend so some stresses here. But if all the fiber and filaments just extend without actually at such a low stress level then why will it go to the break. Anything breaks because you have actually gone to the breaking point right.

And so you might find that while we measuring and there may be reason why we measure. But the properties that we should be concerned about are the properties which define the textured yarn, which is the crimp rigidity and crimp stability. So, let us say if you have time enough to see at least one of them.

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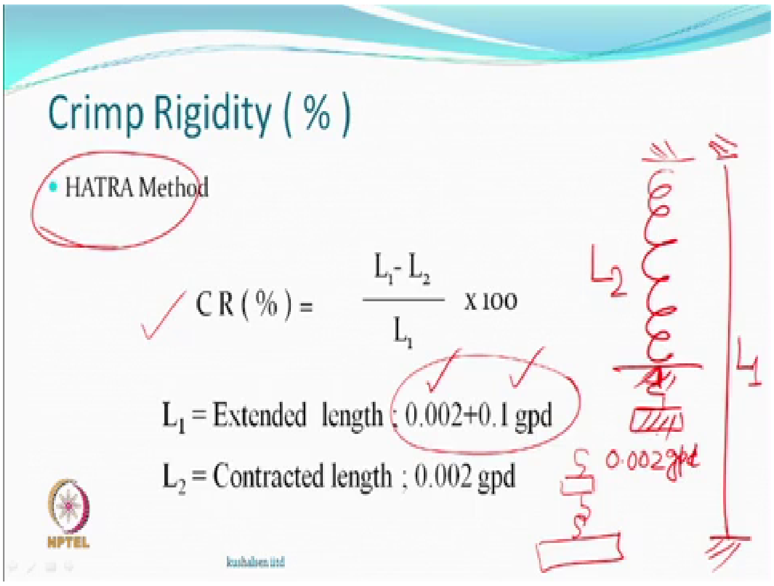

So, crimp rigidity is defined as that if you have this yarn you stretch fully. So, you have let us say we call this fully extended length as L 1. And then you allow it to relax it goes back and contracts the length as L 2. Then this is how you define it that is L 1 if you put a load of this much ok. That means, this relaxation that is happening also has certain load let us say 0.002 grams per denier, you see very small stress right.

What it means is that you how do you measure. So, this standardization is that full extension is not an issue if you will have a load of just 0.1 grams per denier, all the crimps are gone. And theoretically you may have extended up to 300 percent all right. But so you have two loads one is called the light load and the other is called a heavy load. So, initially you put both the loads, let us say it also has some hook. So, you have a light load another hook and you have a heavy load this is how you hang.

So, initially you hang the total load which is the summation of the two loads and then remove the heavy load and allow you to contract. Of course, for a certain time you can do infinitely, say let us say I go it for one minute and then you measure the L 2 and then describe this, this will be called the crimp rigidity alright. Although one could have said one should call it as a crimp recovery you know. But the term has stayed it is called rigidity because some rigidity within the so called helical structure is responsible for it to attain this shape right.

Therefore, this term rigidity has stuck has stuck to us in the textured thing and this was called a HATRA method; HATRA was like hosiery and allied textile research association. So, this was in England. So, they generated this method and this method is what it is used. So, we should stop here because we may have something else to do today. And next time when we meet will pick it pick from here and go further all right.